A comparison of root architecture and shoot morphology between natural regenerated and container seedlings of *Quercus ilex* L.

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The problem

The poor survival and growth of *Quercus* plantations in the field has, in most cases, been attributed to the low quality of the planted seedlings and the limited resources.

Natural regenerated *Quercus ilex* seedlings' emergence and survival *are* facilitated by co-occurring woody plants, since seedlings appear mostly under shrubs and pines sites.

Nevertheless, it is still unknown why the Mediterranean oak container-seedlings with a rich and well-developed root system, face difficulties to survive in the field.

The aim

This study we had four specific goals:

(i) to determine shoot morphological characteristics among 1-year old natural regenerated and container seedlings of *Q. ilex*

(ii) to describe root architecture (included topology and morphology) of the above seedlings,

(iii) to find any correlations between the most root and shoot characteristics and finally

(iv) to explore any differences in mechanism developed by *Q. ilex* natural regenerated seedlings compared to container-seedlings.

Materials and Methods

Study areas for the natural regenerated seedlings

Selection and extraction of the natural regenerated seedlings

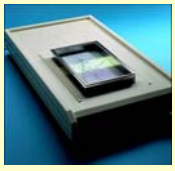
1 year-old seedlings were collected from open woodlands, mixed stands and monospecific stands. Root excavation method consisted of digging a deep enough trench and at a distance from the excavated individual as not to damage its root system. Then small hand tools and hands were used to reach near the roots in order to avoid the loss of lateral roots and finally the entire seedling removed.

Container seedlings production

Container-grown 1-year-old seedlings of *Q. ilex* were produced in a previous study of Tsakaldimi et al. (2005), at an open-air forest nursery.

Root and shoot measurements

Measurements were done: Shoot height, root collar diameter, number of leaves, biomass, SRL, root system morphology and root topology. An image analysis software (Delta-T Devices Ltd. Cambridge, England) was used for root morphology estimations (total root length, taproot length, root image area and total root volume). The topology of the root systems was analyzed visually on scanned root system of each seedling using Fitter's terminology (Fitter, 1985; 1987).



Results

Type of seedlings	Shoot biomass (g)	Root biomass (g)	Total biomass (g)	Shoot to Root ratio
Average Container seedlings	5.5 (0.42) *	3.7 (0.21) *	9.2 (0.61) *	1.5 (0.06) *
Natural-regenerated seedlings	0.4 (0.04) c *	0.4 (0.03) c *	0.8 (0.07) c *	1.1 (0.06)c *

Type of seedlings	magnitude (μ)	altitude (α)	log (α)/log (μ)	α/E(α)
Average Container seedlings	178 (14.0) *	62 (4.6) *	0.8 (0.01) *	1.45 (0.08)
Natural-regenerated seedlings	24 (3.4) *	18 (2.1)*	0.95 (0.01) *	1.38 (0.05)

Type of seedlings	Shoot height (cm)	Root collar diameter (mm)	Leaf number
Average Container seedlings	29.3 (0.8) *	4.56 (0.07) *	37 (4.0) *
Natural-regenerated seedlings	13.17 (0.99) *	2.45 (0.1) *	5 (0.3) b *

Type of seedlings	Taproot length (cm)	Total root Length (cm)	Root surface area (cm^2)	Total root volume (cm^3)	SRL ($cm\ g^{-1}$)
Average Container seedlings	14.5 (0.4) *	665.3 (49.1) *	110.1 (7.9) *	5.03 (0.4) *	81.1 (7.6)
Natural-regenerated seedlings	19.4 (1.1) a *	66.5 (6.5) c *	47.19 (4.1) c *	1.57 (0.2) c *	90.2(8.4) b

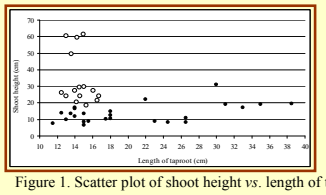


Figure 1. Scatter plot of shoot height *vs*. length of taproot for 1-year old natural regenerated (●) and container seedlings (○) of *Q. ilex*.

Figure 2. Scanned images of two representative root systems of 1-year-old *Q. ilex* seedlings, one from container seedlings (left) and one from natural regenerated seedlings (right).

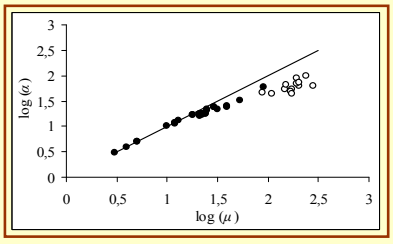


Figure 3. Altitude *vs*. magnitude of root systems of 1-year old *Q. ilex* seedlings, (●) natural regenerated seedlings, (○) container seedlings. Reference line: strict herringbone topology (———).

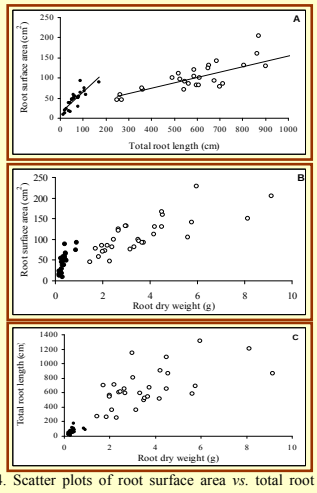


Figure 4. Scatter plots of root surface area *vs*. total root length (A), root surface area *vs*. root dry weight (B) and total root length *vs*. root dry weight (C) for 1-year-old *Q. ilex* container (○) and natural regenerated (●) seedlings. Trend lines fitted to linear regression.

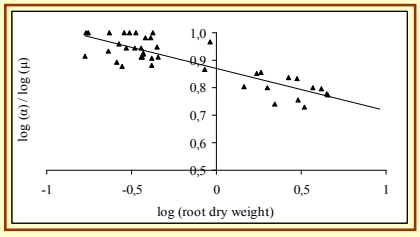


Figure 5. The quotient log(α)/ log(μ) *vs*. log(root dry weight) for all studied 1-year old *Q. ilex* seedlings. Trend line fitted by the regression (Y= -0.152x + 0.87, R2= 0.74, P<0.01).

Conclusions

This study describes for the first time the root architecture (included topology and morphology) and shoot morphology of 1-year-old container- and natural regenerated seedlings of the Mediterranean oak (*Q. ilex*) and illustrates some important aspects of root topology in relation to seedling's size of this species.

✓All container seedlings were superior to natural regenerated seedlings in shoot and root morphological characteristics but they had a restricted taproot length compared to the natural regenerated seedlings, indicating that they employing different morphological strategies.

✓All root systems of all studied seedlings showed a marked tendency toward herringbone branching. However, the container seedlings had a more extended root system while the natural regenerated seedlings presented a strict herringbone root system, with a single root axis and one order laterals.

✓ The quotient log(α)/log(μ) showed a tendency to decrease with plant size for all studied seedlings.

✓From the results obtained, we can surmise that a strict herringbone system with an elongated taproot at the expense of shoot dimensions and root branches may be the optimal formation for *Q. ilex* seedlings in order to survive under the Mediterranean site conditions.